AN ANALYTICAL STUDY OF PRECIPITATION VARIABILITY AND PERSISTENCE OF DRY AND WET PERIODS WITH SPECIAL REFERENCE TO ILLINOIS

BY

RICHARD HSIEN FENG PAO

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AN ANALYTICAL STUDY OF PRECIPITATION VARIABILITY AND PERSISTENCE OF DRY AND WET PERIODS WITH SPECIAL REFERENCE TO ILLINOIS

The object of this analytical study is to examine the variability and persistence characteristics of rainfall, based on rainfall records in the State of Illinois, and to discuss the effects of such characteristics on the well-being of mankind. Rainfall is the source of all water supplies and any large change, deficit or superabundance, in the normal amount of rainfall in a region, may upset the economy. A protracted period with rainfall persistently below the normal has been found disastrous to water supplies. The persistent drought conditions during the period of 1930 to 1934 caused many failures in water supply. This analytical study outlines the degree and extent of variability and persistence of rainfall in the State of Illinois, during the recorded period of 1901-1950, and sketches their effects on water supplies as related to a variety of human purposes, including agriculture, domestic and industrial uses and many others.

Since every hydrological problem is almost unique in nature, an enumeration and brief description of various water uses in relationship to human activities have been presented with special emphasis on the reliability of rainfall as a primary source of water.

Average rainfall in any locality is only of general interest and may serve as an index of the probable availability of moisture over an extended period of observation, while fluctuation of rainfall is manifestly the controlling factor in estimating the reliability of rainfall as a recurrng supply of water. Since the criteria of most hydrological schemes are based on comprehensive knowledge of existing data from which probable extreme conditions in the future may be esti-

mated, the ranges of variation in rainfall as well as percentage occurrences of rainfall in various lengths of period have been determined. The probable extremes in annual rainfall have also been estimated using the technique of statistical analysis.

In general, the variability of rainfall increases with decrease in the time unit being concerned, thus, in any one locality, the monthly rainfall is more variable than the yearly. Geographically, southern Illinois is subject to more abundant as well as more variable rainfall. The average coefficient of variation of annual rainfall for southern Illinois is about 15% larger than either of the two other sections — northern and central Illinois. This same figure holds true for the recorded range of annual rainfall, i.e., the ratio of maximum to minimum rainfall totals.

In practical sense, the variability of rainfall can be viewed upon as an index of reliability of rainfall. For any one area, the economic development depends largely on the availability of water and the dependability of the source of supply of water. In Illinois, this point can be most convincingly illustrated when the rainfall record is compared with the agricultural statistics. The fluctuations of yearly corn yield in the State of Illinois followed closely the variations in summer rainfall. A careful study of the existing 61-year (1890-1950) record revealed that, without an exception, subnormal yields occurred in years in which the summer rainfall amounted to less than 8 inches. A supply of adequate moisture in the growing season is essential to a good harvest.

Although Illinois rainfall is generally adequate for agricultural uses in normal years, there were years in which rainfall in the growing season was far below the amount required for effective consumptive use. Besides, persistent drought periods were not infrequent in growing seasons, especially, in July and August when moisture was most needed for a successful corn yield. The occurrence of persistent drought is in effect one of the main causes of crop loss in Illinois.

The persistent occurrences of dry and wet periods for

months with rainfall totals below and above the mean thus far experienced in Illinois are in close agreement with those computed by the "law" of probability. Altogether thirteen station-records in Illinois have been analyzed. The assumption of persistent occurrences of dry and wet periods in Illinois being fortuitous is well-established since none of the records exhibits any discordance with the chance occurrences expected by the "law" of probability. These thirteen stations are geographically well-distributed throughout the State, hence the results should be a fair representation of the general condition in Illinois.

The writer has limited his treatment of the subject to those characteristics of rainfall concerning the variability and persistence that will have direct bearing on the supply of water. It should be emphasized here that, like all hydrological problems, progressive improvement in better understanding of these natural phenomena can only be gradually achieved through careful observations and intelligent analyses. The practical application of the results of analysis should always be governed by the principle that judgment is essential in all engineering problems.

VITA

Richard Hsien Feng Pao was born on April 22, 1926, in Ningpo, Chekiang, China. After graduating from St. John's Middle School in June 1945, he entered St. John's University, Shanghai, China, and received from that institution the degree of Bachelor of Science in Civil Engineering in May 1949. He began his graduate work at the University of Illinois in February 1950 and was awarded the degree of Master of Science in February 1951. He held a Fellowship in the Department of Civil Engineering, University of Illinois, from February 1951 to June 1953.

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